Presidential Address for 1999-2000
Geodiversity: "green" geology in action

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Geodiversity is the whole range of natural Earth features and processes. Geoheritage consists of all the significant Earth features and continuing processes that we wish to keep, sustain, conserve, manage and interpret for their natural heritage value. The geodiversity practitioner is involved in all the phases of the geoheritage process: identification, documentation, conservation, management and interpretation. Identification can proceed by a variety of means, but is incomplete without field checking. Documentation not only involves describing the place, but also determining its significance. Determining significance is quite difficult, but can be aided and made more reliable by the use of systems of criteria. Description also entails determining the boundary of a place, using cadastral, natural, topographic, significance, catchment and natural system perimeters. Protective buffer zones may also be required. Conservation can be undertaken by legal means or by negotiation, but will not succeed unless there is management that produces continuous protective care of the significance of the place. Many attempts at legal protection have failed due to the lack of proper management. Interpretation is not only vital to increase public understanding of geoheritage places; it is an essential part of the conservation and management process. Geoheritage is a challenging area in which to work, requiring a broad knowledge of the Earth sciences coupled with expertise in, and commitment to, natural heritage conservation.

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INTRODUCTION

When I meet people in Akubra hats and tell them that I am a geologist, they always ask me to give them a share of the gold I find. People in white construction helmets think I have come to solve their foundation or groundwater problems. Such are the popular images of geology and its role in society.

Biologists, on the other hand, do exciting and important "green" things like saving whales, furry things and rare plants. There is however, a "green" branch of the Earth sciences variously called geodiversity, geoheritage, geological heritage, or Earth science conservation, concerned with saving the geological equivalents of whales, furry things and rare plants.

Conserving, managing and interpreting significant Earth features is well advanced in the UK, USA and in former Eastern Block countries such as Slovenia and the Czech

Republic, but not in Australia. Here it runs a very poor third after biodiversity and cultural heritage.

In 1996, the Australian Natural Heritage Charter established geodiversity as an essential element of natural significance to be considered in heritage conservation. This has had some impact at the Federal and Local Government level, but is yet to have a significant effect in New South Wales at the State level, where planning laws and land management policies are made.

Geoheritage practice involves identifying places with potential significance, determining their extent and characteristics, assessing their significance and developing conservation, management and interpretation strategies. Most heritage workers lack the necessary Earth science background and most geologists and geomorphologists lack an understanding of the principles and practice of heritage conservation.

WHY GEODIVERSITY?

Sharples (1993 and 1995) introduced geodiversity into the Australian literature. Discussion by Dixon (1996), Wilkins and Osborne (1996) and Semeniuk (1997) followed. Geodiversity as a term has not been universally popular and during the 1990s its use caused a major split among geoheritage workers in Australia.

Supporters of geodiversity were concerned that traditional approaches, as implied by terms such as *geological heritage*, were too narrow. Public and academic perceptions had greatly narrowed the range of features considered geological, often to the exclusion of important features such as landforms and soils. It was felt that a new term was necessary that encompassed the whole range of natural Earth features. The term, *Abiotic*, favoured by some conservation agencies, was also considered inappropriate as many Earth processes have a biological component.

The Australian Natural Heritage Charter (Cairnes 1996) defined geodiversity as "the range of earth features including geological, geomorphological, palaeontological, soil, hydrological and atmospheric features, systems and earth processes". Geodiversity is not intended to be a scientific concept. It is a technical term used in natural heritage conservation. Geodiversity does not imply that heritage conservation should particularly emphasise those places with the greatest range of Earth features. Geodiversity means identifying and conserving significant examples from the whole range of rocks, minerals, fossils, structures, landforms, soils, rivers, lakes, springs, etc., and places where Earth processes are occurring. Taken together biodiversity and geodiversity encompass the focus of this Society, "natural history in all its branches", called the "whole realm of nature" by 18th century naturalists and hymn writers.

PRACTICING GEODIVERSITY

In New South Wales, and most other jurisdictions in Australia, geodiversity elements are not legally required to be considered in environmental impact statements, plans of management or state of the environment reports. While flora, fauna and archaeological surveys will be undertaken if a major development is proposed, geoheritage surveys are unlikely to occur.

Most work for geodiversity practitioners comes from the public sector, particularly from Local Government and the Australian Heritage Commission. The work required is usually site specific, generating a few days work here and there, certainly not sufficient to make a living.

Large jobs, which are rare, inevitably involve hiring casual staff; however finding people with a suitable background is not easy. Staff must understand local/regional geology

obvious choice, but today many have field areas in other countries, distant parts of Australia, on the seabed or under the ice. Often they have little knowledge or interest in the local or regional environment. Most have been taught not to read the local literature or papers more than five years old. It is possible to find suitable staff after considerable searching.

The work of geodiversity practitioners is surprisingly similar to that of exploration geologists. The initial step of identification is exploration, but the object is not high-grade ore, rather places of significance. Determining the significance, condition and exact boundaries of the identified place is akin to finding the grade and tonnage of an ore body.

IDENTIFICATION

The first step is to determine what is significant and where it is located. While the step itself is obvious, how it should be done is not. A number of approaches have been taken each of which produces a particular type of outcome.

Expert Polling

Expert polling is a process by which experts in a field are asked to nominate places they consider significant to a list or sit around in a group and develop a list. This process is biased by those who choose to reply to requests for nominations or by those who are chosen to participate in workshops. Expert polling is a rapid and cheap way to produce lists of potential places for later investigation.

This method was used by Percival (1979) to add 100 extra potential sites to the list of 100 geological sites previously assembled by the N.S.W. Geological Sites and Monuments Sub Committee of the Geological Society of Australia.

Places identified by expert polling tend to have irregular spatial distribution (close to participant's institutions or field areas) and low type diversity. Places west of Dubbo and in the New England region were poorly represented in Percival's list, while Early Palaeozoic fossil localities and central volcanoes were predominant.

Public Nomination

Members of the public will often nominate places to the Register of the National Estate or council heritage registers. Some of these places are well known and recognised by the scientific community, while other places will have their significance substantially overstated.

Sometimes local community members will nominate places that have not been previously recognised. Good examples are the Elizabeth Street Faults exposed in a road cutting in suburban Newport, north of Sydney. When residents brought the place to the attention of Pittwater Council in 1999, they thought the dipping sandstone beds were an outstanding example of cross bedding. Site inspection (Osborne and Osborne 2000) revealed that the beds were dragged down by a pair of normal faults not previously recorded either in the literature or on geological maps.

Desktop Survey

A desktop survey can be used where a large area is to be covered and funds are scarce. The fundamental assumption behind a desktop survey is that reliable and useful information can be found from the literature, maps, remote sensing, databases and other sources that can be brought to the desk. Desktop surveys produce lists of potentially significant places. Without field investigation, it is impossible to be sure of the existence, location, significance, condition or boundary of a place.

An extreme example of a desktop geoheritage survey was undertaken as part of the Comprehensive Regional Forest Assessment process. The survey (Osborne et al. 1998) was of the Upper North East, Lower North East, South and Eden Regional Forest

Assessment Regions in New South Wales. The survey area covered most of the east coast and the eastern portion of the highlands of New South Wales, some 160,000 square kilometres, represented on ninety four 1:100 000 scale topographic maps. Over a period of four months the project identified 1,746 places of potential significance of which 1,241 (71%) had not been identified in previous surveys. Four months was insufficient to effectively cover all of the available literature and at least another six months would have been required to complete the project.

Regional Approach

Regional approaches are often favoured because they fit in with practical demands for planning information. The regional approach to geodiversity was considered so significant that the Australian Heritage Commission held a workshop on the topic in 1996 and the papers from it were published (Eberhard 1997). The success of the regional approach depends on how the regions are selected and defined, and on understanding the pitfalls inherent in the methodology (Osborne 1997).

Regions based on catchments or local government areas may appear to be of little use for studies with a focus on bedrock geology, but such regions may be very important as they form the basis of land management. If regions are based on natural zonation (e.g. geological provinces) or given natural boundaries, it is absolutely essential to ensure that the significance of features located on the boundary is not ignored. Major faults and unconformities at the boundaries of geological provinces may be more significant than the rocks on either side of them. It would not be of much use if regional studies of the Sydney Basin and the Lachlan Fold Belt ignored the unconformity at Kanangra Walls, or if studies of islands and coastal areas stopped at the high water mark.

Thematic Approach

Thematic surveys, such as a survey of vertebrate fossil sites (Willis 1993) or my work on New England Karst (Osborne 1998), have the advantage that places are being identified and assessed by a specialist in the relevant area of study. The topics of thematic studies often reflect the availability and enthusiasm for conservation of specialists in particular fields, rather than any planned approach or decision about which themes need investigation.

ASSESSMENT AND DOCUMENTATION

Literature Survey

Once a potential place has been identified it needs to be documented and assessed. The first stop is usually at the library to find out what, if anything, is known about the place.

Looking backwards.

Information about places of geoheritage significance is sometimes found on the World-Wide Web or in the latest journals. In most instances, however, the work of 19th and early 20th century geologists and naturalists needs to be consulted, often in rather yellowed volumes of this Journal. Other important sources include the *Annual Report of the Department of Mines*, *Records of the N.S.W. Geological Survey* and unpublished reports such as the Department of Mineral Resources GS series. On occasion the trail will lead to the dome of the Department of Lands building in Bridge Street, Sydney, where old maps and plans are stored.

Often the historic literature will provide not only the best description and maps of the place, but also photographs from which the condition and integrity of quite small features can be judged. Edgeworth David's work on glendonites at Huskisson (David et al. 1905) includes a detailed site map of the locality, which can still be used. Surprisingly some large boulders shown on his map continue to be useful reference points. The

photographs in David et al. (1905) allowed the subsequent survival of the glendonites in the rock platform to be evaluated. There appeared to have been little change or obvious deliberate damage between 1905 and 1996 (Osborne 1996).

Reading between the lines

The older literature is a great source of information about unusual and spectacular features. Writers in the older literature frequently commented on features that were not the prime focus of their research and described them in great detail even if they did not know what they were. Due to poor base maps and a tendency of some people to get lost, the location data is sometimes difficult to interpret and reading between the lines, tracing paths and finding out about non-current locality names is required.

While most modern scientific writers know where they are, they don't record much about anything that does not fit into their particular, very specialised, view of the world. A different type of reading between the lines is required here. Questions such as what soils or landforms might be associated with a particular rock type regularly need to be asked.

Thank God for library angels

Some places just don't want to be found, and the literature doesn't help. Several visits to the reported position of the Ramstation Creek limestone locality, near Dungog, between 1995 and 1998 failed to find any limestone. The map reference given on the relevant geological sheet (Roberts et al. 1991) seemed to match the location given by Jaquet (1901) and Carne and Jones (1919), but no limestone could be found. Just when I was about to give up and assume this was another nonexistent locality a library angel came to my rescue. A map (Jaquet and Harper 1899) fell out of a back pocket in *Memoirs of the Geological Survey of New South Wales* volume 2. The copy I had looked at previously had no map. The map not only showed the location and shape of the Ramstation deposit, about 1 km west of where I was looking, but also the location of three other deposits that had eluded me. It also became clear that although the Ramstation deposit had been described or noted by Carne and Jones (1919), Anon (1948), Lishmund et al (1986) and Roberts et al. (1991) none of the authors since Jaquet (1909) had actually been there and unfortunately neither have I.

The super secret

People love to have secrets. This is particularly the case with "special" places like fossil and mineral localities and limestone caves. The specimen or photograph seems to gain extra significance if "I can't tell where it came from, but isn't it wonderful". Restricted circulation publications, strict membership criteria, secret maps and hidden databases are all used to restrict secrets to the few and "worthy". Most secrets are known to a much wider population than their keepers ever imagine. Accessing "secret" information is rarely a problem, but deciding what to do with the information can be.

Well-known places with no literature

Many well-known features, both geological and geomorphological, are not mentioned in the scientific literature. Places nominated by academic experts often include their favourite student excursion localities. These are usually outstanding examples of some particular type of feature, but no one has ever bothered to describe them in a refereed journal.

Tourist promoters, land managers and the public at large vote for iconic places with their lookouts, feet and cameras. What the public and the tourist industry consider important, however, is often quite different from what professional scientists value and describe. Some of the most visited places in New South Wales include the sea cliffs at North Head and the Three Sisters in the Blue Mountains. To my knowledge there is no published scientific literature on these features. As a consequence it can become quite difficult to demonstrate the significance of places that everyone agrees are significant.

Location

Finding the place

If a location is mentioned in the literature it should be possible to pinpoint it on a

map and find it in the field. Published locations, however, are frequently wrong. Some reported occurrences simply don't exist and some are duplicate records of other places, but with wrong locations. Most incorrect locations result from cumulative errors, poor initial reporting, mirror-image map copies, changing systems of grid references and poor or no archiving of data.

Some of the most difficult problems arise when authors of compilations and review documents allocate precise locations to vague references given in original texts, without making any attempt to confirm the information. One team of compilers gave a precise grid reference based on statement in Carne and Jones (1919) that: "S.R. Beatty, District Surveyor, Maitland, has reported the occurrence of two deposits of limestone on the northern side of Arundle River, one about 9 and the other $10^1/_2$ miles W.N.W. of Copeland".

Another trap for the unwary comes from 1:100, 000 scale geological maps and their accompanying guidebooks. Most provide excellent information and location data. Some of these maps, however, extend over more than one standard 1:100, 000 sheet, and as a result over a grid zone boundary. In these cases the grid references on one part of the map (and in the notes) will not correspond to those on the standard 1:100, 000 and 1:25, 000 topographic maps for the same area.

As a result of these and other difficulties, my survey of karst in the eastern New England (Osborne 1998) was not able to locate 15 out of 61 (25%) published limestone localities.

Unrealistic expectations

Land management authorities frequently have quite unrealistic expectations of what can be achieved from a desk survey. At best, a desk survey will give positions with an error circle of approximately 1 km on a 1:100, 000 scale map. That is assuming the place really exists.

Those who can't or won't fund fieldwork often expect that desk surveys will not only produce precise grid reference data (+/- 10 m or 100 m), but also legal boundaries and management recommendations. These expectations are clearly a dangerous fiction.

Ownership and management

It is important to know who owns and who manages the places you wish to conserve. While it is fairly easy to determine who owns places with freehold title, increasingly state laws and local government planing instruments have a great influence on what you can do in your own back yard. It is vital to know not just who owns a place, but what the owners are legally allowed to do with it.

Who actually owns and manages land in public ownership and land with less than freehold title is not always easy to determine. Frequently there are overlapping levels of management and disjunctures between legal precision and practical reality. It may be more important to discover who mows the grass and who empties the garbage bins than to know the name on the title, who pays the rates or which body holds the land in trust. It is essential to do the administrative searches and to talk to the person driving the tractor.

One must never assume that fences, roads or even buildings are in the right place, that people really own their back yard or that land which the council manages as a park is a public reserve or council-owned land. Professor T.W.E. David unveiled a large painted wooden sign at Seaham Quarry, north of Raymond Terrace in 1926, which concludes; "Science trusts that the People of Seaham will kindly preserve this quarry intact for the benefit of future generations." Everyone assumed that the quarry was public land, but surveys in the 1980s revealed that it was private property. The quarry was eventually purchased and is now part of Seaham Nature Reserve.

The need for red lines on maps

The world of land tenure and land management depends on red lines on maps. To conserve or manage a place requires a well-defined boundary that can be marked on plans and laid out on the ground by a surveyor. Locations defined entirely by a single grid reference, a dot or unbounded shading on a map will not do. While exploration geologists have great experience in pegging out claims, surprisingly some academic geologists and

geographers appear not to appreciate the importance of defining a place as an area (or volume) with a definite boundary.

Small places and the problem of many maps

It is often necessary to use a series of maps with differing scales to usefully locate small places. Fossil and mineral localities, some structures and springs are often less than a hectare, and may have an area of only a few square metres. While it may be possible to use a single plan to legally define their location, their significance will often relate to their regional or even continental geological or geomorphological context. As a consequence more maps may be required for the proper documentation of a small place than for a large one.

Tenure blind or not?

One of the most controversial issues in heritage identification is where one should look. Should places of significance be identified wherever they occur, or should land with some types of ownership or use not be evaluated for heritage significance?

Some landowners, and categories of land users, argue the initial decision that land can be used for a particular purpose (residential, agricultural, forestry, mining) precludes it from subsequent heritage assessment. I, and many others, respond that heritage assessment should be tenure blind, particularly since many decisions about land use were made a considerable time ago, without any assessment or consideration of the impact of the designated use. This issue is particularly important in the case of land uses such as mining and waste disposal, where the designated use is likely to occur for a very brief period of time relative to the likely natural life span of either ecosystems or geoheritage features.

Surprisingly, some state conservation agencies have argued that their reserves contain a complete and sufficient sample of all features of natural heritage significance in their state and that there is nothing of significance outside their reserves.

Description

A useful description must tell the reader what is there, allow them to recognise the significant features and understand why these features are important.

Thinking about the audience

Reports about places with geoheritage significance are rarely read, or used, by Earth scientists. They are mainly used by land managers, landowners and by council planning officers. Most of these people are unfamiliar not just with the language and concepts of the Earth sciences, but also with the idea that Earth features could be significant or worthy of conservation and management.

Because professional conservationists, land managers and planners are so familiar with protecting and managing the living environment and the "rich tapestry of our priceless cultural heritage", the description must highlight geoheritage significance in an unambiguous way.

Object lessons of management not understanding what is significant at geoheritage sites abound. Examples include a landcare group planting trees on a naturally bare scoria cone, and millions of tourists visiting the lookouts at North Head being told about the shrubs behind them, but not about the cliffs or the view they went to see.

Since the audience of the report is unlikely to recognise geoheritage features by name, (What's a brachiopod, glendonite, fault, ria...?), maps, diagrams and photographs with scale, are an essential component of any description.

The Statement of Significance

The statement of significance is a key component of heritage listings, conservation plans and management plans. It is a concise statement about why the place is significant, and should form the basis for future conservation and management. The statement of significance must be technically precise, yet comprehensible to non-specialists.

A special style

Since statements of significance have to be brief and contain a large amount of information, a particular style of writing has developed. The general form of these documents, usually less than an A4 page in length, is something like this:
"The X (place) is an outstanding example of a Y (feature). It exhibits Z (rare or unusual characteristic) to a degree not seen elsewhere in the region. The place is largely undisturbed and sub feature 1 and sub feature 2 are found in a rare state of preservation...."
For geoheritage places this style presents considerable problems. The readers are likely to have a reasonable understanding of statements like "contains species x and y, listed as endangered in New South Wales" or " is the most intact surviving Victorian cemetery". They are far less likely to understand or value "one of the few examples of Tertiary leucitite in Australia".

Writing a statement of significance forces you to consider why a feature is significant and then to explain this concisely.

Condition and Integrity

Condition

It is important for a report to describe the present condition of a place. Is it a pristine forest, is it a mass of noxious weeds or an abandoned quarry partly filled with metallic farm waste and old bottles?

It is important for the report to focus on the condition of the significant features at the place. The significance and condition of geoheritage features is usually unaffected by impenetrable noxious weeds, which often protect rather than harm. As a consequence what might be a disaster zone to an ecologist, may be a site in excellent condition to a geodiversity practitioner.

Integrity

It is important to distinguish between condition and integrity, as both factors my have a bearing on the significance of a feature. A single fossil of the whole organism although in poor condition may be more significant than a large deposit of well-preserved pieces (e.g. a whole trilobite *vs* lots of pygidia, an intact crinoid *vs* thousands of columnals).

Integrity becomes an important issue if a significant place is modified or damaged after it has been documented and placed on a heritage register. How much can the integrity of a place become compromised before it looses its significance? This difficult question can only properly be answered if the condition and integrity of the place were well documented initially.

Current condition vs threat

It may be clear that there are threats to the condition and integrity of a place. While some make efforts to evaluate threats, others consider that documentation should only consider the place's current condition and integrity.

There have been two responses to dealing with places that are clearly at risk. The usual response is to say that if a significant place is threatened, then there is a strong case for documentation, listing and protection. The less common response is to do nothing where places are likely to be compromised or destroyed by a known legal activity, because it has already been decided that they will be destroyed.

Boundaries

One of the most difficult and important issues is where to draw the boundary. In conservation, planning and land management the position of a boundary has important legal and financial implications. Heritage listing or changes in zoning may be positive or negative to landholders' interests in the order of millions of dollars. This makes it very important to determine a boundary that not only will result in the place being conserved, but can also be defended before administrative tribunals and the courts.

A confusing outcome of different approaches being taken to boundary definition is that some places have multiple entries with different boundaries in the Register of the

National Estate. One geological example is the Warrumbungle Volcano in central New South Wales. The Warrumbungle National Park is listed on the register and defined by its cadastral boundary. The Geological Society of Australia's nomination of the Warrumbungle Geological Site, also listed, is based on a boundary designed to include all significant features following Percival (1979). This is a much more complex boundary, and covers a larger area than the national park, including areas of freehold land outside the park boundary.

A number of different approaches can be taken when defining a boundary, each of which has quite different consequences for conservation and for people with an interest in the affected land.

Cadastral boundary

The simplest method of defining a boundary is to follow land tenure boundaries. If most, or a significant part, of a feature is in a reserve, national park, road reserve or within a single freehold Portion or Allotment, then the boundary off the title plan becomes the boundary of the place.

This approach has two real advantages; the boundaries are already legally defined and only one landowner has to be dealt with. The disadvantages of using cadastral boundaries can be considerable. Significant natural features, particularly landforms and geological structures, are rarely restricted to a single rectilinear Lot or Portion. Similarly, processes that are likely to impact on the conservation of a feature are not often restricted to its exact physical location.

Topographic boundary

Topographic features such as streams, cliff lines and ridge tops would appear to make good boundaries, but where do you actually draw the line? Should the boundary be the top of the cliff, the base of the cliff, or some distance out from the base of the cliff so as to include rockfall and scree? While these types of boundaries are easy to plot from air photos and topographic maps, they are not so easy for surveyors to measure and define in the field. Boundaries based on contours are likewise attractive, but imagine constructing a boundary fence along a contour.

Inclusive significance boundary

If our aim is to "retain the natural significance of a place" (Cairnes 1996, p 10), surely it makes sense to draw a boundary that includes all its significant elements, irrespective of topography and land ownership. Inclusive boundaries are easy to justify, but often have complex and inconvenient shapes. These boundaries take no account of the surrounding environment or of practical issues such as tenure and management.

Inclusive boundaries can result in "shrink wrapping", which produces small discrete sites whose context is not retained. These are extremely difficult places to manage. Where a feature is unrelated to its surrounding environment, is very small, or is an isolated remnant, "shrink wrapping" is the only practical alternative. A classic example is the Dalton Fossil Leaf Deposit (Percival 1985), which consists of a single boulder of fossil-bearing rock, housed in a wire cage beside the local tennis court in the village of Dalton, southern New South Wales.

Exclusive significance boundary

An exclusive boundary is produced by looking at a large defined area in which significant features are distributed and then drawing a boundary that excludes those parts of the area which lack significance. Exclusive boundaries will frequently produce a pattern with patches of land with no significance surrounded by, or embayed into, significant areas. Exclusive boundaries can be useful tools for planning development within areas of generally recognised significance, such as national parks or heritage precincts.

Buffer zones

Buffer zones are areas that should be managed in order to conserve the significant places that they adjoin or surround. Buffer zones may be needed to control erosion, protect catchment areas or to provide a physical barrier against people, machinery or vehicles. Since buffer zones generally lack significance themselves, their creation needs to be

carefully justified.

Natural system (ecological) boundary

When ecosystems are being documented for conservation purposes it is normal practice to define boundaries that include, or attempt to include, the whole of the ecosystem in the area of identified significance. Such an approach can be taken with some Earth features, particularly active landform systems. The Earth system boundary of a beach could be drawn to include back dunes on the landward side and sand reservoirs in banks some distance out to sea. System boundaries of a river would include its catchment and estuary, and a karst by its catchment, sink and resurgence. Even if for practical and political reasons a place cannot be formally bounded by its natural system boundary it is useful for buffer zone management to define a natural system boundary.

The adjacent place problem

Many related natural features are not directly adjacent to each other, but separated by land with quite different characteristics. If related features are tens of kilometres apart, it makes sense to consider them as separate places for conservation and management purposes. If, however, related places are a few kilometres or less apart, practical and administrative issues can arise. Should adjacent, related features be considered elements of the same place, or should they each be considered to be a separate place?

While state governments have been prepared to declare national parks and proclaim reserves composed of numerous disconnected parcels of land, the Australian Heritage Commission and others who keep heritage registers have often found dealing with related disjunct elements a difficulty. Most heritage registers were designed to deal with buildings with a discrete location and street address, not features such as chains of volcanic hills, or even small patches of remnant rainforest on the north coast of New South Wales, where this problem initially arose. Since the Register of the National Estate lists "places", and gives them grid references, latitudes and longitudes, how, the bureaucrats ask, can a place have more than one location?

SIGNIFICANCE

What do we mean by significance, and how can we measure or determine it? Joyce (1995), a geodiversity sceptic, considered that "the significance of a geological feature or site lies in its value in research, reference or education at the local, national, international or world level." This definition relates only to utilitarian scientific and educational values. It probably excludes the Three Sisters and many other landforms valued by the community, but not necessarily by professional Earth scientists. The narrow, science-centred, view of significance given by Joyce is derived from an earlier definition of a "significant geological feature' by Legge and King (1992): "...those features of special scientific or educational value, which form the essential basis of geological education, research and reference. These features are considered by the geological community to be worthy of protection and preservation".

While a utilitarian view of significance became dominant among the official geological community, it was not the only view on offer in Australia. Sharples (1995) indicated that geodiversity elements might possess intrinsic and ecological values in addition to their utilitarian value to humans. He also noted that the heritage values (i.e. values to humans) of geodiversity included; aesthetics, inspiration, recreation, cultural development and a contribution to a 'sense of place' in addition to the scientific and educational values noted by Joyce (1995).

This wider view of significance was adopted by the Australian Natural Heritage Charter for both biodiversity and geodiversity which gives the following definition: "Natural significance means the importance of ecosystems, biological diversity and geodiversity for their existence value, or for present and future generations in terms of their scientific, social, aesthetic and life-support value" (Cairnes 1996, p 6).

Significance Criteria and Definitions

It is difficult to decide how to measure or determine significance. One option is to measure significance on a scale (e.g. local, regional, national or international). Another is to define a critical cut-off level, with potential places ranking above the cut-off being significant for a particular purpose (e.g. heritage listing, reservation, consideration in planning instruments) and those below being insignificant.

Significance is determined either directly by the vote of an expert panel, or by measurement against a set of criteria, usually mediated by an expert, an expert panel or a series of panels. The Register of the National Estate uses expert panels to determine significance against a set of criteria and then make a yes or no decision as to whether the place should be listed (i.e. a cut-off decision). Other systems ask experts or panels to use criteria and then rank places according to their level of significance.

In federal systems of government, like Australia's, significance assessment procedures that rank places can have serious political and financial implications. Should local government be responsible for places with local significance, state government for those with regional significance and the federal government only responsible for places with national and international significance? Since state governments run national parks, should the federal government only be responsible for internationally significant places? These questions are currently being debated in Canberra.

World Heritage

The International Union for the Conservation of Nature (IUCN) has the task of advising and assisting the UNESCO World Heritage Centre in implementing the World Heritage Convention. One of the main roles of the IUCN is to evaluate places nominated to the World Heritage List as having "outstanding natural value". The process by which nominated places are evaluated is outlined by Hogan and Thorsell (2000). Article 2 of the World Heritage Convention defines natural heritage as:

> "natural features consisting of physical and biological formations or groups of such formations, which are of *outstanding universal value* from an aesthetic or scientific point of view;
>
> geological and physiographic formations...of outstanding universal value from the point of view of science or conservation;
>
> natural sites and precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty."

It is important to recognise that a standard of "outstanding universal value" is built into each part of this definition. This is a very high criterion; it is not easy to show that a natural place meets this. A key element of the process is comparing the nominated place with other similar places throughout the world. This is designed to ensure that the World Heritage List is " only a select list of the most outstanding...from an international viewpoint".

Specific provision is made for geoheritage places in the World Heritage List. The requirement is that they should:

> "(a) (i) be outstanding examples representing the major stages of earth's history,including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features; or
>
> (iii) contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance."

These criteria are much more inclusive than those of the Geological Society of Australia's concept of geological heritage, but not too dissimilar from the concept of significance given in the Australian Natural Heritage Charter.

National Estate Criteria

Places nominated for listing on the Register of the National Estate are evaluated against a set of eight criteria, some of which are divided into sub criteria (Australian Heritage Commission 1993). Places are ranked high, medium or low against the criteria, and then a decision is made as to whether the place does or does not meet the standard for listing.

National Estate Listing is subject to both administrative and judicial review, and there are cases where both have occurred. As a consequence those involved in the evaluation process are careful to ensure that both the listing of a place and its nominated boundaries can be defended against the most rigorous inquiry.

Only some of the criteria and sub criteria are relevant to geodiversity. Each of the relevant criteria, from Australian Heritage Commission (1993), are given and discussed below. Note that each criterion and sub criterion begins with the word "importance". It is the task of expert nominators, Evaluation Panels, Heritage Commission staff and the Commission itself to decide just how important a place must be for it to be registered.

"A.1 Importance in the evolution of Australia's flora, fauna, landscapes or climate."

Sub criterion A1 is particularly applicable to geodiversity. It can include fossil localities, geological sites that give palaeoenvironmental or palaeogeographic information as well as palaeoclimate sites. Places providing evidence for plate movement could also be included.

"A.2 Importance in maintaining existing processes or natural systems at the regional or national scale."

This is usually thought of as an ecological criterion, however it can just as well apply to any active Earth system of regional scale. River and groundwater systems, aeolian processes in large sandy deserts and regional longshore drift could meet this criterion.

"A.3 Importance in exhibiting unusual richness or diversity of flora, fauna, landscapes or cultural features."

Geoheritage places can be rich and/or diverse. This criterion will admit both rich places with low diversity and diverse places that are not rich. Shearsby's Wallpaper near Yass has abundant well-preserved specimens of two species of brachiopods, while the Delegate Pipes intrusions in southeastern N.S.W. contain "a large variety of rare xenolith types" (Schön 1984).

"B.1 Importance for rare, endangered or uncommon flora, fauna, communities, ecosystems, natural landscapes or phenomena, or as a wilderness."

This has generally been interpreted as encompassing any natural heritage feature that is genuinely rare, endangered or uncommon. A whole range of geodiversity places have been seen to meet this criterion, including: fossil and mineral localities, outcrops of rare rock types (the olivine leucitite at El Capitan, western N.S.W.), meteorite impact lithologies (the Liddell buchite, Hunter Valley, N.S.W.), burning mountains (Mt Wingen, near Scone, N.S.W.) and unusual landforms (Australia's only hum, a type of residual limestone hill, at Mole Creek, Tasmania).

"C.1 Importance for information contributing to wider understanding of Australian natural history, by virtue of their use as research sites, teaching sites, type localities, reference or benchmark sites."

This sub criterion has allowed a very large number of places with potential significance to be generated. There has been considerable discussion about which of these are truly significant. The reason for this is that sub criterion C1 places are an artefact of working natural scientists. A potential C1 place is created every time a scientist does field work, takes students to a specific locality, describes a new species (biological or mineralogical) with a type locality, defines a stratigraphic type section or indicates a soil reference site on a map.

Most natural places that have been nominated to the Register of the National Estate have had C1 as one of a number of highly rated criteria. How to assess the significance of the large and growing number of places which rate highly simply as research, teaching, type and reference sites remains to be resolved.

"D.1 Importance in demonstrating the principal characteristics of the range of landscapes, environments or ecosystems, the attributes of which identify them as being characteristic of their class."

Places that meet this criterion do not have to be rich, diverse, rare, uncommon, or used for science or teaching. They must be an outstanding example of what they are. This criterion says that the best example of something very common can be significant. It is generally seen to incorporate the concept of "representativeness".

A representative example a feature must clearly exhibit the all, or most, of the key features of its class. This is best illustrated by a hypothetical example. Sandy beaches are very common in Australia. A representative sandy beach would have all of its components; bars, swash zone, berm and dunes intact and well developed. It would be the example of a beach you might use in a textbook.

"E.1 Importance for a community for aesthetic characteristics held in high esteem or otherwise valued by the community."

This criterion solves the problem of highly regarded places that are ignored by the scientific community. The criterion talks about "a community", which allows places valued by particular defined groups, ethnic or social also to be included.

"G.1 Importance as places highly valued by the community for reasons of religious, spiritual, cultural, educational or social associations."

At first glance this might appear to be the "churches and war memorials" provision, and these places meet this criterion. Some geoheritage places have great significance to Koori people and as a consequence meet this provision. Other geoheritage places have this type of significance for Australians with a range of ethnic backgrounds. Caves in New South Wales have been used for weddings, church services and Masonic rituals (Jenolan and Wellington), dances and concerts (Abercrombie, Jenolan and Kanangra Walls), by bushrangers (Abercrombie, Cliefden, Coolah and Jenolan) and as a classroom (Wuulumin Cave). Similarly, vantage points used for ANZAC and Easter Dawn Services might qualify under this criterion:

"H.1 Importance for their close associations with those individuals whose activities have been significant within the history of the nation, state or region."

A number of geoheritage places have associations with people considered significant

to the history of European exploration and/or the development of the natural and geological sciences both in Australia and internationally. Particular landforms are associated with or claimed to be associated with the work of early European explorers and surveyors (e.g. Thomas Mitchell and Victoria Pass and the various purported localities of Barralier's Pass in the Blue Mountains, west of Sydney). Another strong association exists between landforms and aviation pioneers (e.g. Hargraves with Bald Hill, and Kingsford-Smith with Seven Mile Beach, both located in the Illawarra Region, south of Sydney). Examples of geoheritage places in New South Wales that have close associations with significant naturalists and Earth scientists include:

PLACE	ASSOCIATED PERSON/S
Black Head, Gerroa	J.D. Dana
David Moraine	Edgeworth David
David's Cutting, Maitland	Edgeworth David
El Capitan Leucitite	A. Harker, Edgeworth David, Milne Curran, Etc.
Fennel Bay Fossil Forest	W.B. Clarke
Govetts Leap	Charles Darwin
Kiama Blow Hole	J.D. Dana and W.B. Clarke
Mt Gibraltar, Bowral	Douglas Mawson, W.R. Browne
Mt Wingen (Burning Mountain)	Thomas Mitchell
Mt Woowoolahra	Douglas Mawson
Seaham Quarry	Edgeworth David
Soho Street Amphibolite, Cooma	W.R. Browne and Germaine Joplin
Wellington Caves	Richard Owen, George Cuvier, Thomas Mitchell, A.M Thomson, P. Strzelecki, G. Krefft. etc.

Thematic Assessment and the National List

One of the options currently being discussed as a replacement for the Register of the National Estate involves the development of a "National List". The proposal is that the "National List" would include perhaps one hundred places, regarded as being significant at a national level.

The 'Re-drafted National List Criteria, version 9/11/99', produced by Environment Australia, states that:

"The National List will comprise those places, or groups of places, that are of outstanding significance for the Australia community, in that they are symbolic, exemplary or unique places reflecting the agreed themes of national importance (The National Themes).

Places entered in the National List will satisfy each of the following criteria:

Criterion 1. the place must be a symbolic, exemplary or unique example of the highest

order in representing or demonstrating a National Theme; Judgments on the significance of a place will be tested using the sub-criteria listed below.

Criterion 2. the place must have a very high level of integrity in its nationally significant values;

Criterion 3. the place must possess a great capacity to demonstrate its primary National Theme, and places that in addition to this primary criterion also reflect other aspects of natural and cultural diversity will be favoured over places of equal thematic value that do not."

The sub-criteria proposed are very similar to the existing National Estate Criteria.

Possible contexts for the National Themes include: "An Ancient Land", "Continental Isolation", "Settlement of Australia by hunting-and-gathering societies", "European Expansion and creation of nation", and "Encounter between cultures" (Pearson 1999). The following themes related to geodiversity are listed in the first two context areas:

- "Ancient records of life and landforms.
- Origin and development of biota and landforms as a result of Gondwana plate tectonics and more recent stability and long isolation.
- Evolution of landforms, species and ecosystems under conditions of stress.
- Climatic change and its impacts." (Pearson 1999, p 18)

It has been suggested that the National Themes should form the basis for promoting regional heritage tourism. The really important issues about National Themes are those concerning who develops them and on what basis are they developed. This remains to be seen.

Comparison with similar places

Most heritage assessment procedures require that a proposed place or item of heritage significance should be compared with similar places. In some systems this means similar places or items already listed, while in other systems it means other known similar places in the region, country or world. Fortunately, Solar System wide comparisons have yet to be considered, for if they were, basaltic volcanoes and impact craters on Earth would quickly be delisted.

Comparing places, even those of the same general type, is never easy. Two of the problems that arise are: how similar do the places need to be for a comparison to be valid, and to what extent do differing regional settings add to the significance of otherwise similar places? The latter question applies to a comparison between a relict sand dune in the Blue Mountains and a dune of similar age and size in a desert region. The setting of the relict dune would make its comparison with the dune in the desert invalid. A valid comparison would be with other relict dunes, located away from modern deserts.

Objections to heritage listings are often made on the basis of comparative significance. One, from a mining company, went something like: "this is not be best example of feature x, but we won't tell you where the better examples are located".

CONSERVATION

The Australian Natural Heritage Charter (Cairnes 1996) defines conservation as:"all the processes and actions of looking after a place so as to retain its natural significance and always includes protection, maintenance and monitoring". There are some special aspects to each of these essential components when geodiversity is being conserved.

Protection

Protection involves using legal or social measures to ensure that the values of the place remain intact. There are a number of ways in which this can be attempted. I use the word 'attempted' advisedly, because legal and social measures can never be guaranteed to work. Sometimes protective measures can actually encourage destruction of, or damage to, the place they were intended to protect.

Protection by secrecy

There is a long history of using secrecy as a means of protecting limestone caves, fossil sites and mineral/gem localities. In the case of limestone caves this practice goes back to the early 20th century when, as legend has it, the chief guide at Jenolan Caves, Vos Wiburd, hid cave entrances by landscaping and burnt his notebooks following a dispute with his employer, the Department of Mines. Practices of this type have been undertaken by caving clubs since the late 1940s, with secret maps, restricted access publications, restricted access data bases, landscaped entrances and whispered conversations continuing to be used.

The danger from management by secrecy is often not the wrong people finding out, but the proper authorities never finding out, and as a consequence failing to take appropriate action. If a secret place is really secret, then professional planners and land managers will not know about it. Local government planners will not take it into account, so it may be threatened by inappropriate development.

Should the self-appointed custodians wish to take legal action to protect the place from some threat they will face the accusation that as the place is not recorded it either is not significant, or has been "discovered" simply as an excuse to stop the development. The motives of the secret-keepers may also be questioned. Those wishing to protect the caves at Mt Etna in Queensland were accused of wishing to use the caves (illegally) for their own exclusive recreation. Similar accusations could be levelled at mineral and fossil collectors with secret localities on other people's land.

This dilemma occurs when producing publications from heritage reports (e.g. Percival 1985). If the place is an open secret and it does not appear in a published list, it could be taken to indicate that it is really not so special after all. Secrets can be revealed in unexpected ways. The online version of the Register of the National Estate gives locality details for a fossil locality, followed by a condition report saying that the main threat to the place's integrity comes from its location being more widely known.

Protection by reservation

It is a tradition in Australia that very important places are best protected by being placed in public ownership in a reserve or National Park. There is a long history in New South Wales of geoheritage places receiving such protection and recognition. Some significant examples are given in the following table:

PLACE	DATE	RESERVE CATEGORY
Wombeyan Caves	1865	Protection of Caves
Bungonia Caves and Gorge	1872	Water Reserve
Slaven Cave	1888	Not specified
Yessabah Caves	1890	Pubic Recreation
Colong Caves	1899	Preservation of Caves
Fennel Bay Fossil Forest	1904	Protection of Fossil Trees
Hattons Corner	1927	Public Recreation
Talbragar Fish Beds	1970	Preservation of Fossils and Access

Despite their innovative timing and promise, in most cases these reservations failed to protect the significance of the places over which they were declared. Reserves declared to protect caves, even those specifically dedicated for the "preservation of caves", did not exclude mining (Middleton 1969) and in some cases acted to encourage it. Reserves over fossil localities usually had no trustees appointed and no bylaws to make removal of fossils illegal. In the case of the Fennel Bay Fossil Forest, reservation was a total failure. Practically all of the fossil tree stumps (estimated at 500 by Clarke 1885) have been removed, with only 30-40 remaining in 1979 (Percival 1979).

National Parks, Nature Reserves and Karst Conservation Reserves offer the highest level of protection to natural heritage in New South Wales and prohibit mining. That does not mean that they offer a high level of protection to geoheritage places. The National Parks and Wildlife Act has a strong fauna and flora focus. There is no guarantee of specific management for geoheritage places and penalties for offences against non-living elements are weak.

In New South Wales some geoheritage sites, particularly fossil and mineral localities, have a better history of protection on freehold land under the care of resident owners (with fences, dogs, suspicion of strangers etc.) than on public land.

Protection by legal intervention

Legal intervention is very expensive in both time and money and highly unpredictable as a means of protection. Legal action can usually only be triggered by an active or "real and present" threat to the place. Win or loose, the process creates polarisation and ill will, which is difficult to overcome. The legal system is often more concerned with correct process rather than environmental outcomes. Court decisions are good at stopping particular events or letting them occur, but they do not always form the basis for ongoing protection and management. As a consequence of legal action, mining ceased at Yessabah Caves near Kempsey, north coast of N.S.W., in 1991 (Osborne 1994), but the site has not been rehabilitated and the lantana continues to flourish.

Protection by planning instruments

Local government planning instruments, such as Local Environment Plans and Development Control Plans, can be powerful tools for protecting geoheritage places of all types on both public and freehold land. Large-scale sites such as landforms and geological structures are often best protected by zoning that prevents land uses such as rural residential subdivision, which may obscure views. Small places may be protected by restrictive zonings, such as "7J Scientific", but this requires careful negotiation with landowners.

In the current climate of corporatisation, privatisation and sale of surplus land, zoning may be the only mechanism to keep public sector landowners in check, unless the Minister decides to override local planning approval.

Protection by agreement

The future for a geoheritage place is often most effectively assured when its owners have entered into a conservation agreement with a State or Local Government body. This is particularly the case with small places located on rural properties.

Conservation agreements can provide funding for fencing and conservation works and in some cases reductions in Local Government Rates, in exchange for an agreement to protect the place. The landowners retain their rights to control access. Resident owners frequently provide policing and management at a level not available on public sector lands.

Some landowners develop long-term, sometimes multi-generational, relationships with scientists and other user groups. An example of this situation is at Cliefden Caves where two generations of landowners have maintained excellent relationships with palaeontologists and the Orange Speleological Society.

Maintenance

Preservation without maintenance can lead to destruction. Cairnes (1996) defined

maintenance as "continuous protective care". Lack of "continuous protective care", rather than defective legal protection, allowed the Fennel Bay Fossil Forest to be largely removed.

As a conservation strategy, maintenance includes enforcement, fencing, weed control, erosion control and drainage. Enforcement does not necessarily mean patrols by rangers and security officers. It is the chance of being seen or caught that is by far the best deterrent to vandalism. The major advantage of resident landowners is being there, caring for the place, fixing the fences and applying the "heel of the owner" to the weeds.

Monitoring

Managers of public places set aside for conservation are required to produce Plans of Management or Conservation Plans that outline how the significant features of the place will be conserved and maintained. These plans can be comprehensive multi-volume reports or simple recipe book style documents produced to keep various levels of bosses and the interested public in their place.

Sometimes few of the actions outlined in the plan take place, and without monitoring we are none the wiser. If the plan has got it wrong, the values may be destroyed, rather than conserved, in the time between the development of one plan and its successor. Even though large sums of money may be spent on producing a plan, it may not be implemented simply because the management authority has lost their copy.

Monitoring does not have to be elaborate (with instruments, sensors, data loggers etc.), a simple look-see will often tell you if all is well or not.

Conservation vs Use or Collection

One solution to damage by humans is to limit or prohibit access or particular activities. Fencing off public areas, blocking tracks, restricting walkers to paths and gating caves are not universally popular among the outdoor recreation community. Similarly prohibiting or controlling collecting will quickly raise the ire of lapidaries, fossil collectors and some professional educators and scientists.

Four wheel drive enthusiasts, trail riders (bike and horse), bush walkers, teachers, youth leaders, rock climbers, cavers, ecotourism operators, respectable members of this Society and many others all want to be able to do their thing, because it is always someone else who does the damage. As a consequence land managers often do their duty at some peril.

Ownership by discovery

One of the most common and fallacious arguments facing land mangers arises from the assumption that those who discover something own it, are entitled to unrestricted use of it, or should determine how it is used. The notion of ownership by discovery is found among palaeontologists, fossil and mineral collectors, and is particularly prevalent among cavers.

Discoverers often view those with legal ownership and/or responsibility for management of *their* discovery with distain and suspicion. "I found it, what right do they have to tell me what to do", is a view frequently expressed.

Should anyone use/access?

If something is significant and really fragile, perhaps people should be kept away completely, no matter who they are or what they wish to do. This approach can vary from forcing people to view the feature from afar to entirely preventing access.

People may question the value of something they are not able to directly experience. Alternative approaches have been developed which allow a visitor experience while keeping people away from the feature itself including building an artificial replica adjacent to the real feature (as at Lascaux Cave, France), exhibiting photographs and models of the feature and using film, video or computer technology to produce a virtual experience.

Who should use/access?

If it is decided that some people will be allowed in and most will be excluded, there needs to be a proper rationale for doing so. Allowing some people access or use on the

basis of merit is a guaranteed way to promote disputes. Bona-fide researchers are often given privileged access, but can this always be justified as beneficial to conservation and management?

Where significant features occur in areas used for commercial tourism there is a simple (but not necessarily socially equitable) solution. Make access to the most fragile features expensive and thus keep visitation down. This occurs at Jenolan Caves.

If a vulnerable place is a public asset, such as a National Park or reserve, how can the access or use privileges of a particular group be favoured against those of the population at large? Access and use privileges in Australia have frequently centred on questions of merit. Real scientists, walkers and members of accredited rock climbing and caving groups have been the winners. Amateurs, people in cars, parents with children in strollers and competent adventurers who don't join clubs (or belong to the wrong ones) have often been excluded.

From a conservation and management perspective the only relevant questions are not *who* the prospective users are, but what their impact will be on the place and will they be able to undertake the activity without unacceptable risk to their own or public safety. This is not always a popular view.

In the U.S. National Parks a ballot system is used to determine who is able to undertake some over-popular treks, and in Western Australia access to some delicate caves is limited to a fixed number of visits in the applicant's life. These systems solve some of the problems inherent in controls based on merit.

Should anyone collect?

If the Fennel Bay Fossil Forest was found today we probably would not allow the petrified logs to be used as railway ballast or fencing materials. A land manager today would take their responsibility to keep the site intact seriously.

Studies of collected specimens may greatly enhance understanding of the place, with benefits to management and interpretation. On the other hand, advances in technology may make some forms of collecting obsolete in the near future. High quality imaging, 3D rendering and lightweight portable instruments for chemical and mineral analysis are already reducing the importance of the hand specimen. A thoughtful manager might say to a researcher; "come back when you no longer need to collect".

Following well-known disasters like the extinction of the Dodo, biologists have developed ethical collecting protocols. At a basic level these are that you don't collect the only living specimen and you don't collect so much of a population as to threaten it's survival. Earth scientists rarely give consideration to ethical collecting. In my field of research, working in heritage-listed caves, the issue of ethical collecting is never far away. Micro sampling, indirect sampling and ensuring that excavations leave stratigraphic sections intact, are the orders of the day. There have been geological collecting events that have verged on the dodesque! In the 1930s the Australian Museum collected over one thousand specimens of stalactites, stalagmites, helictites and crystal clusters from Cliefden Caves in order to construct an exhibit (Hodge-Smith 1936).

Issues to be considered in managing collecting include:

- ensuring a sufficient range and quantity of material is left intact for future research
- managing and limiting collateral damage from collecting
- ensuring that the amount collected is not greater than is really necessary
- ensuring that non-collecting methods are considered, before collection takes place
- deciding whether the best specimen should stay in situ, or be moved to a museum.

Who should collect, how and what should they take?

Where the significant features are abundant and their survival in situ is unlikely there is no need to control collecting. Mulbring Quarry in the Hunter Valley of N.S.W. exposes highly fossiliferous siltstone, used for road metal. In the normal course of events

the fossils will be broken and compacted into roads. Continuing quarrying operations expose more fossils, acting as a form of self-management (Stevenson 1981). While there is no conservation reason to control access or collecting, public safety, security and liability issues need to be considered.

When a resource is scarce, collecting may be the greatest threat to its survival. Placing reference specimens in collections, however, may be the geoheritage equivalent to keeping threatened species in zoos. It is reasonable to argue that only specialists should undertake this type of collecting and that very good reasons need to be given to justify additional collecting.

Land managers who treat requests from intending scientific collectors with suspicion do so with the benefit of hindsight. The history of vertebrate fossil collecting from New South Wales caves (Osborne 1991) includes examples where leading researchers removed deposits in their entirety, made no stratigraphic observations and kept no proper records of provenance. Much of the "cart loads" of bone in museums collected during the 19th century are of little value. Some collection sites can't be reinvestigated because there is nothing left.

Modern controls on collecting must ensure that collection of fossils for taxonomic studies, for instance, does not make future stratigraphic or palaeoecological studies impossible. Collection based studies must be able to justify the damage done to the site by collection on the basis of tangible benefits to management and interpretation.

Where should the collections go?

Collecting does not cease to be an issue when the rock, fossil or mineral is removed from the ground and carefully packaged for transport; in fact some of the most complex and intractable issues are just beginning.

The first issue, which must be resolved, but often isn't, is who owns the specimen? Collectors, both amateur and professional, frequently assume that once they dig it up and write an institutional specimen number on it, that they, or their institution, are the owners. This is usually not the case. Most often the specimen remains the property of the landowner or managing state or local government authority; the exception is where statutory collecting rights exist, eg Geological Survey staff. Whoever owns the specimen has the right to decide what should become of it. There are a number of issues to be considered in making such a decision:

- can the specimen be wholly or partly destroyed, or must it be kept intact?
- should the specimen be preserved or disposed of at the end of the current study?
- if the specimen is to be disposed of, can it be destroyed, sold, swapped or gifted?
- if the specimen is to be preserved where, by whom and under what conditions?

When it is decided that the specimens should be preserved, the issues of where and by who can become complex and emotive. There are a number of worthy, competing alternatives that need to be considered:

- significant specimens should be housed in state or national institutions
- specimens can be housed in overseas institutions and at a range of teaching and research institutions, giving status and recognition to the place
- all specimens should be housed in a repository at the site
- type specimens should be housed in state or national institutions, all others should be returned to the site and housed in a repository at the site
- the specimens should become the property of the appropriate state collecting institution
- all specimens should remain the property of the owner/management authority of the place, specimens not on site will be considered to be on loan.

There are good arguments for and against all these propositions. Whatever is decided, much angst will be avoided if clear decisions are made at the outset.

ACTIVE PHYSICAL INTERVENTION

Many places are best conserved by doing very little, but in some cases there is a need for quite substantial intervention.

Regeneration

Regeneration involves allowing natural processes to restore something of significance. It is most appropriate for conserving partly disturbed living systems where regrowth and reproduction can, over time, repair the damage. Partly disturbed active landforms such as beaches and dunes do have a capacity to regenerate, as do some (but not most) constructive chemical deposits (rim pools, tufas and some speleothems). The significant features of most geoheritage places, however, don't regrow or reproduce.

Stabilisation (Preservation)

This involves enhancing the physical strength or resistance of the significant features to weathering and erosion. It is a form of preservation because it attempts to slow or stop natural processes.

Stabilisation can involve a range of techniques such as sealing, impregnation, grouting, rock bolting, reinforcing with rods, physically supporting etc. The main problem with these types of interventions is that once installed they require perpetual maintenance. Without maintenance the intervention may often cause more long-term damage than would have otherwise occurred. Use of chemically unstable sealants or steel rods that rust, can result in problems that require expensive remediation.

Hardening (Preservation)

Hardening is one of the most effective ways to preserve places from damage such as wear, trampling and breakage, caused by high levels of visitation. Typical hardening measures include concrete paths, rails and protective fencing, which increase resistance to the effects of people. Poorly designed or installed hardening can be intrusive and detrimental to the visitor experience.

Hardening is the only option if visitation exceeds a few thousand per year or the place is easily damaged. Hardening has been standard practice at fragile places such as show caves, but is becoming more common at places that attract large visitor numbers. Substantial hardening has been undertaken at North Head, Sydney Harbour, to prevent erosion and trampling.

Scaling (Restoration)

Bedrock features exposed in artificial outcrops are frequently obscured by weathering and slope debris. Cleaning or scraping back the surface of the outcrop can reveal the significant features. Scaling, as a restorative activity, should be distinguished from scaling for public safety/geotechnical purposes, which, while an essential management activity, may threaten the significance of the place.

Re-exposure (Restoration or Enhancement)

Re-exposure involves removing more than a small amount of obscuring dust or debris from a feature. It can be restoration if the obscuring mantle is a result of a recent rockfall, or enhancement if the obscuring material has been in place for a considerable time.

While re-exposure may enhance the view of a feature, it may make it more vulnerable to weathering and erosion and other natural elements may be degraded in the process. Proposals to re-expose a site must be carefully evaluated and not undertaken lightly. Short-term advantages of improved views need to be weighed against increased maintenance and possible reductions in life expectancy of the feature.

Re-burial (Preservation)

Some features are preserved best by being buried, or re-buried. This is the case with features exposed through excavation. For re-burial to be considered, a feature must be so significant that its preservation outweighs the need for it to be seen. Features must also be more likely to survive under an artificial mantle of earth than at the surface.

Re-burial is rarely used and does not always have the desired effect. The hominid footprints at Laetoli, Tanzania were re-buried, but were later exhumed and re-buried again following damage by the roots of trees growing in the earth covering the site.

Protective salvage (Preservation)

Protective salvage is removing significant material from a place to protect it from destruction or damage from imminent natural or human causes. Protective salvage is most often used to remove fossils from danger. Alex Richie (Australian Museum, Sydney) has been involved in a number of salvage operations including recovering fish fossils at Eden, south coast N.S.W., before they were destroyed by natural retreat of a sea cliff and at Somersby, near Gosford, N.S.W., where they were exposed in an active quarry.

Protective salvage agreements, such as that at Somersby, can be made with quarry operators, but are difficult to arrange. There must be a high level of trust between the operator and those involved in salvage and trained personnel must available on call carry out the work quickly. Unfortunately much is lost because operators feel it is too dangerous to the continuation of their operation to report interesting material that they may unearth.

Reinstatement

Reinstatement is putting something back into the environment that was once there, but is now missing. Most bush-regeneration projects are actually reinstatement. Proposals to clone mammoths and thylacines are extreme examples of reinstatement.

Reinstatement is rarely, if ever, appropriate in geoheritage places. Initially, the only example I could think of was replacing broken stalactites using araldite and splints, but better and larger scale examples are the artificial sand dunes constructed behind surf beaches along the New South Wales coast.

INTERPRETATION

Interpretation involves building a bridge between a place and those that visit and manage it. We are apt to think that visitors are the main audience for interpretation, but unless owners and managers understand and value places in their care, the chances for long-term conservation are poor.

Lack of community knowledge

The main problem confronting geodiversity interpretation is a lack of community knowledge and understanding. While many in the community have some understanding of elementary ideas in biology, ecology and biodiversity conservation, there is very little community understanding of the basic ideas of Earth science.

One reason for this lack of information is a lack of accessible literature. It is relatively easy to obtain popular information about local flora and fauna. There are many general books and a number of specific guides, particularly to regional flora. There are very few comparable publications about rocks, landforms and soils. Similarly, interpretation material produced for National Parks, and programs run by environment centres, visitor centres and field study centres, almost exclusively focus on the biological, and are usually produced and managed by staff without much knowledge of geology.

This does not mean that there is a lack of public interest in geodiversity, just that there are few mechanisms for engaging that interest. It is difficult to convince editors, producers and teachers that Earth features and processes (with the possible exception of

dinosaurs, earthquakes and volcanoes) are interesting, or worth the risk, when sharks, killer whales and cuddly animals have well-established, and regenerating markets.

Research for Interpretation

The lack of mainstream scientific interest in geoheritage places with general public interest has created the need for applied basic research to provide a basis for interpretation and to answer questions frequently asked by the public.

Questions raised by interpretation are often complex and multidisciplinary. They do not lie within conventional disciplinary research programs, nor are they likely to be answered by industry-based applied research. Much of my research at Jenolan, Wellington and Wombeyan Caves has been directed towards answering two questions frequently asked by visitors; "how old are the caves?" and "how did they form?"

There have been numerous attempts to improve geodiversity interpretation and education in New South Wales (Osborne 1992; Wilkins and Osborne 1996). Making worthwhile and lasting progress in this area remains one of the greatest challenges for the future.

CONCLUSIONS

Practicing geodiversity requires a range of skills and an approach to the Earth sciences not frequently found among academic or professional geoscientists. Expansion of work in geodiversity will largely depend on changing the attitude and focus of politicians and nature/heritage conservation policy-makers. The introduction and adoption by some Local Government organisations of the Australian Natural Heritage Charter is a significant move in this direction.

Geodiversity has the potential to provide a whole new sphere of employment for Earth science graduates. For this to occur there will need to be a change not only in the content of their training, but also in the values and attitudes instilled in them. The time for regarding Earth scientists working in heritage conservation as traitors to the profession has long since passed.

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A NOTE OF THE LITERATURE

The references include a number of works from the "grey" literature as well as conventional books and journals. Much of this material is held in the libraries of the NSW Department of Planning, NSW National Parks and Wildlife Service, NSW Department of Mineral Resources, and Environment Australia (Canberra). Copies of unpublished consulting reports are generally available from the commissioning agencies.

NOTE ADDED IN PREP

There have been a number of significant developments in the political environment of geodiversity conservation since the Presidential Address in March 2000. In April, the Office of the Sydney Harbour Manager launched the "Spectacle Island Statement for Conserving the Natural Heritage of the Sydney Harbour Catchment". This six-page document contains a statement on the geodiversity of Sydney Harbour.

In July, the final meeting of the NSW Natural Environment Evaluation Panel of the Australian Heritage Commission was held. This probably marks the beginning of the end of both the Register of the National Estate and the Australian Heritage Commission. Public briefings were held in August to explain the proposed new Commonwealth approach to heritage and the National List. Legislation is apparently to be placed before Federal Parliament in 2001. The future of geoheritage identification and documentation in New South Wales looks bleak unless the NSW Heritage Council and/or the National Parks and Wildlife Service (or some other body) takes up the role formerly played by the Australian Heritage Commission.

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